RECOVERED MATERIALS PRODUCT RESEARCH FOR THE COMPREHENSIVE PROCUREMENT GUIDELINE V

Draft Report
June 2003

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MANURE COMPOST

1. Item Description

As directed by the U.S. Environmental Protection Agency (EPA), Eastern Research Group (ERG) conducted research on the use of manure compost in the United States.

EPA has previously designated yard trimmings compost and food waste compost as part of the Comprehensive Procurement Guidelines (CPG). Therefore, this research focused on manure compost.

Composting is the controlled biological process of decomposition of organic matter in the presence of air to form a humus-rich material which provides organic matter and nutrients to the soil. Mature compost (in which the composting process is completed) is composed of small brown particles, resembles soil, and is free of pathogens and weed seeds. The Composting Council defines mature compost as follows:

> *Compost is the stabilized and sanitized product of composting; compost is largely decomposed material and is in the process of humification (curing). Compost has little resemblance in physical form to the original material from which it was made. Compost is a soil amendment, to improve soils. Compost is not a complete fertilizer unless amended, although composts contain fertilizer properties, e.g., nitrogen, phosphorus, and potassium, that must be included in calculations for fertilizer application (59 [Federal Register] FR 18877).*

Mixed organic materials, such as manure, yard trimmings, food waste, and biosolids (waste-water treatment plant sludge), must go through a controlled heat process before they can be used as high quality, biologically stable and mature compost (otherwise it is considered mulch, manure, or byproduct) (Rynk, 2002a). Compost has a variety of uses and improves soil quality and productivity as well as preventing and controlling erosion (Grobe, 2002a).

Animal manures, applied in solid, semisolid, and liquid forms, have traditionally been used as a direct source of nutrients for crop production, although it is typically not characterized as a fertilizer (for the purposes of the CPG, organic fertilizers were considered as a separate item). In addition, organic components of manure can increase soil organic matter, resulting in soils having increased waterholding capacity, increased water-infiltration rates, and improved soil stability. These changes can reduce wind and water erosion of soil. Manures stimulate the growth of beneficial soil microbes, increase microbial activity within the soil, and increase the population of beneficial organisms such as earthworms (Wright, 2002).

Animal manures vary widely in chemical composition, physical properties, and moisture content. The nutrient content of manure varies with animal species, type of diet, growth stage and level of performance of the animal, production system used, amount of supporting material with the manure, and method of manure storage and handling (TMECC, 2002).

Compost can be used in a wide range of applications. It can be used as a substitute for peat moss, potting soil, topsoil, or other organic materials in agriculture, horticulture, silviculture (growing of trees), and in landscaping. In landscaping, compost is used as a soil conditioner, soil and lawn amendment, potting soil mixture, rooting medium, and mulch for shrubs and trees, and for restoration and maintenance of golf course and other sports grounds. Compost also can be used for treatment of contaminated soils, contaminated stormwater runoff, volatile organic compound emission reduction, and reclamation of mining sites (Wright, 2002).

2. Recovered Material Content

Manure compost is composed of 10-100 percent manure taken from farms, racetracks, feedlots, dairy barns, poultry houses, and swine operations. This range may include manure and other excrement contained in animal bedding, which is typically added as a bulking agent in the compost process (Rynk 2002b). Bulking agents, which comprise the non-manure portion of the compost, provide structure, allow air to circulate more freely, and increase carbon content of the compost (Alberta Agriculture, Food and Rural Development, 2002).

3. Impact on Solid Waste

Using manure compost has great potential to make beneficial use of a large amount of the manure produced in the United States. In addition, other materials that are used as bulking agents in manure compost, such as sawdust, extruded rice husks, straw, leaves, wood chips, corn stalks, and ground tree and shrub trimmings, can be diverted from the solid waste stream as well.

Generally, manure generated on farms is applied directly to crop fields as a soil supplement. Larger livestock farms give the manure away or sell it directly to neighboring farms for agricultural application, and sometimes store excess manure on location. Some larger farms pay for manure removal, which is then sold through a broker to a third party (Rynk, 2002c).

In the United States, beef cattle generate 27 million tons of manure solids annually and dairy cattle in confinement produce approximately 21 million tons of solids annually. Swine produce about 16 million tons of solid waste annually. In 1990 there were approximately 330 million acres of cropland and 650 million acres of pasture and rangeland in the United States, providing abundant space for application of animal manures (Wright, 2002).

Earthwise Organics in California composts over 180,000 tons/year of the 1 million tons of manure produced by dairy farms in the Chino area. The composted manure is supplied to over 1,500 users, mainly farms, thus helping to reduce the problems of excess manure in intensively farmed valleys. Since 1998, Earthwise has processed 500,000 tons of manure into 300,000 tons of compost (Rynk, 2002a)**.**

4. Technical Feasibility and Performance

As mentioned previously in Section 1, compost can be used in a variety of applications including:

- Soil enrichment: agriculture (soil conditioning, fertilizer amendment, erosion control, development of marginal lands, mulch, rooting medium, sod production); silviculture; horticulture.
- Pollution prevention (reduced chemical use and nonpoint source pollution, reduced VOC emissions).
- Pollution remediation (treatment of contaminated soils and reclamation of mining waste).

Use of manure compost helps reduce reliance on synthetic chemical fertilizers, and thus reduces the amount of chemicals entering the environment. Under USDA's National Organic Program (NOP), organic farms, which by definition do not use synthetic pesticides, herbicides, or fertilizers, may not use biosolid-based compost, such as waste-water treatment sludge, if they wish to keep their organic certification. This means a greater demand for manure-based compost. One requirement of certified organic farming is the use of natural fertilizers and compost (Cramer, 2002). Although a commercial compost operation may become USDA certified, it is not required to do so, and a certified organic farm is not required to use certified organic compost. However any compost used by an organic farm must meet the requirements of USDA's NOP regulations, section 205.203. These regulations require that raw manure be composted unless it is applied to land used for a non-food crop or unless a food crop is harvested after a reasonable period of time from the last application of manure (USDA, 2002).

According to a contact at OMRI, compost made from manure from livestock that have been treated with hormones or antibiotics is still considered acceptable for use on an organic farm (Douglas, 2002).

Organic food sales are currently $11 billion a year and are growing by approximately 20 percent a year (Batsell, 2002). As the demand for organically grown goods increases, the demand for compost used for organic farming will likely increase (Cramer, 2002).

If improperly managed, the manure generated by beef feedlot and dairy operations can create significant environmental problems, including human health issues caused by contamination of surface water and groundwater (Wright, 2002). Using manure as a raw material for compost, as opposed to applying it directly to the land or stockpiling it, can alleviate many of these problems, while providing an important agricultural service.

On December 16, 2002, EPA and USDA finalized a rule that will require all large Concentrated Animal Feeding Operations (CAFOs) to obtain permits, submit annual reports, and develop and follow plans for handling manure and wastewater. This rule should encourage feeding operations to compost their manure as an agricultural or landscaping product. This will not only benefit the environment, but more of this compost will be available to government purchasers.

Regarding a connection between *E. coli* and manure, a representative of the California Certified Organic Farmers states "While not all manures carry *E. coli*, manure is a documented source of *E. coli* contamination and should thus be handled cautiously in a fresh produce production system. Well-composted manures are recommended over the use of raw manures." The Organic Trade Association adds that *E. coli* , *salmonella*, and other pathogens found in manure can be reduced by proper composting. (OTA, 2002).

a. Standards

There are a variety of reference materials and guidelines available on manure compost but no existing national or state regulations or laws regarding manure compost in particular. Most states have their own regulations governing composting facilities and the marketing of compost products (Recycling and Composting Online, 2002). According to a contact with Biocycle magazine, the National Resource Conservation Service (NRCS) within the Department of Agriculture is currently developing draft guidelines for manure compost (Rynk, 2002c).

The U.S. Composting Council (USCC) is helping to define and develop industrywide standards for composts made from various combinations of materials. The USCC has developed protocols, called Test Methods for the Examination of Composting and Compost (TMECC), which are standardized methods for the composting industry to test and evaluate compost and verify the physical, chemical, and biological characteristics of composting source materials and compost products. The TMECC also includes material testing guidelines to ensure product safety and market claims (USCC, 2002). The TMECC guidelines form the basis for a grant from the EPA to the U.S. Composting Council to develop a Seal of Testing Assurance (STA) for the commercial composting industry (TMECC, 2002). The STA program includes standards for testing procedures of composted materials for nutrients, moisture, salt content, and chemicals (Mallet, 2002). The USCC's goal is to get all composters to participate in the program and to have compost purchasers, regulators, and users accept only STA-certified compost for their projects. Finally, the USCC’s Uniform Bills committee has been given a directive to develop a draft "Model Compost Law", which it is still working on (USCC, 2002).

The U.S. Department of Transportation’s (U.S. DOT) *Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects 1996* specifies mature compost for use in road construction (U.S.DOT, 1996). This specification would be applicable to use of manure compost.

In general, on-farm manure composting comes under minimal regulations, which may include requirements to notify the proper authorities of compositing activities (Grobe, 2002b). EPA; some state agencies, such as the Washington State Department of Ecology; and some local agencies have established guidelines concerning compost production. For example, for a region in the State of Washington, the final authority on manure compost rests with the Whatcom County Department of Health and Human Services, which has established rules based on a tiered system of feedstock qualities (Cramer, 2002). USDA, pursuant to the recently passed Farm Bill, will be issuing guidelines on biobased products, which would include composts made from plant or animal byproducts.

b. Benefits

There are numerous benefits of composting, including the following:

- Destroys weed seeds and pathogens.
- Decreases bulk of raw inputs.
- Finished compost has a consistent soil-like quality that makes it easier to handle and apply.
- Stabilizes nutrients as organic compounds.
- Stable organic nutrients release more slowly, providing plants with a more sustained source of nutrients for growth.
- Results in odorless, marketable product.

There are a few drawbacks to composting as well, including the following:

- Emissions of ammonia, carbon dioxide, methane, nitrous oxide, and volatile compounds, especially in the early stages.
- Runoff from compost piles must be controlled to prevent contamination of ground or surface waters.
- Aeration and moisture must be managed throughout the process.
- Time, equipment, and land are required.
- Some additional fertilizer may be needed to meet crop requirements.

(Government of Saskatchewan, 2002)

Nutritional Benefits

Manure found in compost is a source of many nutrients, including nitrogen, phosphorus, potassium, and others. Nutrient content and rate of availability varies widely, depending mostly on manure source, handling methods, and water content. However, nitrogen is often the main nutrient of concern for most crops. Generally, poultry manure is highest in nitrogen content, followed by hog, steer, sheep, dairy, and horse manure. Feedlot steer manure must be applied at fairly high rates to provide adequate first-year nitrogen amounts because of its lower nitrogen content and gradual nitrogen release characteristics. However, this leads to higher nitrogen availability in succeeding years, allowing for lower annual application rates to support plant growth (Ecochem, 2002).

Table 1. Manure Nutrients. (Typical)

	Nitrogen (N)	**Phosphorus (P_2O_5)**	**Potassium (K_2O)**	**Calcium (Ca)**	**Magnesium (Mg)**	**Organic matter**	**Moisture content**
Fresh Manure	**%**	**%**	**%**	**%**	**%**	**%**	**%**
Cattle	0.5	0.3	0.5	0.3	0.1	16.7	81.3
Sheep	0.9	0.5	0.8	0.2	0.3	30.7	64.8
Poultry	0.9	0.5	0.8	0.4	02	30.7	64.8
Horse	0.5	0.3	0.6	0.3	0.12	7.0	68.8
Swine	0.6	0.5	0.4	0.2	0.03	15.5	77.6
Treated Dried Manure	**%**	**%**	**%**	**%**	**%**	**%**	**%**
Cattle	2.0	1.5	2.2	2.9	0.7	69.9	7.9
Sheep	1.9	1.4	2.9	3.3	0.8	53.9	11.4
Poultry	4.5	2.7	1.4	2.9	0.6	58.6	9.2

Source: Ecochem, 2002

Composting converts nutrients into forms that are more stable and less reactive, do not leach, make nutrients more available to plants, and kill weed seeds and pathogens. EPA has concluded that composting can reduce nutrient loading and nonpoint source pollution of streams and rivers (U.S. EPA, 1992).

Microorganisms use many of the nutrients in compost and release them slowly as they die. Nutrients are also converted into forms that bind with humic acids (another byproduct of composting). These acids hold 3-5 times more nutrients than inorganic soil, holding the nutrients at the surface near the roots. This helps increase availability and prevents leaching. Composting reduces the carbon-to-nitrogen ratio in manure, which can prevent the immobilization of nitrogen by microorganisms, a problem that can occur when using raw manure (Cramer, 2002).

EPA's research found several references indicating that compost, particularly manure compost, may contain high salt levels. The California Integrated Waste Management Board's (CIWMB's) compost specification elements table states that high salt concentrations (greater than 4.0 Mmhos/cm) can be harmful to plants and seeds. In addition, salinity issues are mentioned in several of CIMWB's organics management fact sheets. One on compost use in orchards states, "Feedstock that contains large amounts of salt, such as animal manure, can result in compost that can be problematic for orchards in which the soil already has a high salt content. However, if the soil in a particular orchard does not have a history of high salt content, salt from compost or mulch should not generally present a problem for Northern California orchards." Another fact sheet on urban compost states "Too much salinity will be detrimental to plant growth. Maximum tolerable salinity level will depend on plant species, irrigation water and soil salinity, amount of leaching due to rain and irrigation, and compost application rate" (CIMWB, 2002). A Colorado State University Web site states that salt levels will be higher in composted manure than in raw manure (Colorado State University, 2002).

Beneficial Organisms

Beneficial organisms stimulated by the use of compost fall into three categories: macroorganisms (bugs, worms, etc.), bacteria, and fungi.

<u>Macroorganisms</u> aid composting through their ability to breakdown materials into small pieces. This creates a larger surface area on which bacteria and fungi can feed. In addition, some macroorganisms are predatory and may feed on harmful organisms.

Bacteria microbes degrade organic matter into forms more available to plants. Many can also fix atmospheric nitrogen and convert it into forms that plants can use, which helps decrease the amount of synthetic fertilizers that must be applied. Recent research has also shown that the bacteria in compost are effective in suppressing some plant diseases. They do this by competing for resources, by secreting antibiotics, and by elevating the plant's own resistance capabilities.

Fungi are essential for the breakdown of organic matter and in compost, fungi are responsible for creating humic acids. Fungi help roots uptake water and nutrients and are essential to plant growth and health. Fungi also free up nitrogen and carbon for use by plants. Finally, some fungi secrete antibiotic compounds that can kill disease-causing bacteria, and some kill and consume larger pests such as nematodes

(Cramer, 2002).

Other Benefits

Compost can be used in landscaping as mulch, which creates a thicker soil boundary layer, protects against frost, and provides a cover that prevents the increase of nutrient- robbing grasses and weeds (Cramer, 2002). Using compost in highly sensitive areas can decrease erosion and allow faster revegetation. Once applied to the soil, compost can increase infiltration by up to 125 percent. Compost controls erosion by increasing water infiltration into the soil surface and reducing runoff. It also improves soil stability by improving plant growth and increasing the water holding capacity of soil. It reduces soil compaction by increasing soil structure and allows new vegetation to be established directly into the soil (CES, 2002).

Composting can reduce the volume of raw manure by as much two-thirds, and it can be applied year-round (Cramer, 2002). It also reduces the moisture content and alters consistency to a more spreadable form. These effects can improve manure handling and decrease spreading cost (Rynk, 2002c).

Table 2. Composition of Compost vs. Raw Manure

	Fresh Manure	**Compost**
Total	1000 kg	1000 kg
Water	700 kg	300 kg
Dry Matter	300 kg	700 kg
Nitrogen	5 kg (based on 1.7% N)	11 kg (based on 1.6% N)
Phosphorus	1 kg (based on 0.33% P)	4 kg (based on 0.58% P)

(Source: Government of Saskatchewan, 2002)

Compost has nearly the same characteristics as peat and can be used as a substitute, reducing the impact to wetlands where peat is extracted. Compost may become a feasible alternative to peat as federal protection of wetlands increases (Cramer, 2002).

Using compost may have some climate-related benefits as well. When analyzing the composting of yard trimmings, EPA found that compost leads to long-term carbon storage in degraded soils. The agency also found that composting, when managed properly, does not generate methane emissions. Properly managed compost is aerated and turned to ensure aerobic decomposition (i.e., decomposition in the presence of oxygen). As long as the yard trimmings decompose aerobically, methane is not generated. EPA also noted that carbon dioxide emissions during decomposition "do not count" towards national inventories of greenhouse gas emissions submitted annually to the United Nations Framework Convention on Climate Change. According to internationally accepted rules, these emissions are considered part of the natural carbon cycle and are not a reflection of human activities. On the other hand, EPA found that composting does result in minimal carbon dioxide emissions during the collection and transport of yard trimmings to the composting facility (U.S. EPA, 2000).

By reducing the amount of chemical fertilizers required, net greenhouse gas emissions are reduced because there is less energy-intensive fertilizer production (Alberta Agriculture, Food and Rural Development, 2002).

5. Economic Feasibility

There are numerous potential markets for manure compost, including:

- Agriculture: Soil conditioning, fertilizer amendments, and erosion control for vegetable and field crops and forage grasses; development of marginal lands; mulching after conservation seeding.

- Silviculture: Landspreading as soil conditioner for evergreen establishment; mulching for woodlot soil improvement and maintenance.

- Sod production: Blending with topsoil to reduce the amount of fertilizer needed to establish sod.

- Residential retail: Soil amendment to enrich planting areas; top dressing for lawns.

- Nurseries: Potting mixes; topsoil amendment for areas in which field grown trees are harvested on a periodic basis.

- Delivered topsoil: Blending with marginal topsoils to produce topsoils used for establishing new lawns and planting trees and shrubs.

- Landscapers: Soil amendment for lawn establishment; top dressing; mulch.

- Landfill cover and surface mine reclamation: Topsoil amendments for lower grade and nonuniform compost products.

(U.S. EPA, 1999)

Manure compost provides a number of economic advantages. If raw manure has to be transported a significant distance, however, transportation costs can easily exceed the value of the manure. According to one contact, manure compost is lighter than raw manure due to a lower moisture content and is easier to transport. It also keeps longer than raw manure due to its makeup, which allows for longer transportation time (Rynk, 2002c).

Manure compost can also greatly offset the use and costs of fertilizers. For example, an Oregon farm estimates that the use of chemical fertilizers will be reduced by as much as 40 percent by using composted dairy manure on crops (Grobe, 2002a).

Organic farming and the horticulture industry are growing markets with opportunities for manure compost. Furthermore, EPA wetland regulations may reduce the availability of peat, driving up its price (USEPA, 1996). Therefore, it is likely that compost will become a more economical alternative to peat.

6. Availability and Competition

EPA was not able to find an estimate of the total number of composting facilities nationwide, but according to EPA's "Municipal Solid Waste in The United States: 2000 Fact and Figures" (EPA530-R-02-001) there were an estimated 3,800 composting facilities for yard trimmings in 2000.

EPA did learn, however, that manure and manure compost are widely available across the country from small farms, industrial size-feedlots, commercial compost producers, and other businesses. The market for compost manure is locally based. For example, Texas Best Compost near Austin provides manure compost for landscape projects, nurseries, large and small farms, and for private use. The company sells to colleges, schools, the Texas Department of Transportation and other public agencies (Johnson, 2002). Magic Valley Compost in Idaho sells 75 percent of its compost manure at 3 tons per acre to small local farms, landscapers, school districts, and golf courses. The company sells more than 65,000 tons a year. The market has been expanding and the company has experienced 95-97 percent rate for repeat customers (Mallet, 2002).

7. Government Purchasing

To assist in the development of federal markets for compost, a Presidential memorandum entitled "Environmentally and Economically Beneficial Practices on Federal Landscaped Ground" was signed on

April 26, 1994. Agencies are encouraged to develop practical and cost-effective landscaping methods that preserve and enhance the local environment. This memorandum requires the use of mulch and compost by federal agencies and in federally funded projects.

The Texas Natural Resource Conservation Commission (TNRCC) is working with the Texas Department of Transportation (TxDOT) to use large amounts of manure compost along designated TxDOT highway land. During the past 18 months, compost operators have seen their sales increase significantly statewide to more than 250,000 cubic yards (Grobe, 2002b). TxDOT is expected to be the largest governmental purchaser of compost, some of which includes manure, over the next few years. TxDOT has already used more than 170,000 cubic yards of manure across the state (Markwardt, 2002). This use is expected to increase dramatically as projects progress. TxDOT has also identified projects among its participating districts that will use in excess of 160,000 cubic yards—more than half of its commitment for the 3-year project. TxDOT has been using compost for both construction and maintenance activities (TNRCC, 2002). It will soon be expanding use of compost for filter berms, which are placed across water channels to filter the water (Markwardt, 2002).

TxDOT has developed new specifications and revised others to increase compost use among its districts. These cover proper application and use of compost for controlling erosion and sedimentation, and for establishing vegetation on roadsides after construction and maintenance activities (TNRCC, 2002). The State of Texas also offers public agencies incentives for purchasing compost manure (Johnson, 2002). For example, the Texas Commission on Environmental Quality approached TxDOT to purchase more compost in order to help alleviate manure problems and associated water quality issues in certain regions of Texas. TxDOT is taking part in an EPA buy-back program, in which EPA pays TxDOT $5 per cubic yard of compost that TxDOT purchases from this region (Markwardt, 2002).

The Idaho Department Of Transportation is also purchasing manure compost for use in new road construction and reclamation. Magic Valley Compost conducts 25 percent of their business with the Idaho Department Of Transportation, which purchased approximately 30,000 tons in the last 4 years. The average size of the projects is 4 to 5 thousand tons (Mallet, 2002).

Government agencies typically use compost and fertilizers for numerous applications, such as landscaping, agriculture, bioremediation, roadside maintenance, and erosion control. Although EPA does not know the exact amounts of these materials used by agencies, we believe it is significant, and that manure compost could be used in many of these applications.

8. Purchasing Barriers

Several efforts and initiatives should reduce any barriers to purchasing manure compost. For example, the U.S. Composting Council's TMECC, which include material testing guidelines to ensure product safety and market claims, and STA, which includes standards for testing procedures, will bring consistency to the industry and ensure quality assurance/quality control. In addition, agencies will be encouraged and find it easier to purchase manure compost as a result of USDA's impending biobased product guidelines, required in the recently passed Farm Bill. Executive Order 13101 also encourages the purchase of biobased products.

Although using manure compost for certain applications may involve higher initial costs, EPA believes over the long term, manure compost will be cost-effective.

Potting soil, top soil, and peat moss have long established markets that could make it difficult for manure compost to increase in overall market share (Wright, 2002).

9. Manufacturers, Distributors, and Other Contacts

a. Product Manufacturers and Distributors Contacted

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ORGANIC FERTILIZERS

1. Item Description

As directed by the U.S. Environmental Protection Agency, Eastern Research Group (ERG) conducted research on organic fertilizer use in the United States. Although compost has some fertilizer qualities, for the purposes of the CPG, compost is considered a separate category and is not included in this discussion of organic fertilizers.

The U.S. Department of Agriculture (USDA) defines a fertilizer as “A single or blended substance containing one or more recognized plant nutrient(s) which is used primarily for its plant nutrient content and which is designed for use or claimed to have value in promoting plant growth”(USDA, 2002).

All plants and crops require nutrients (both macro and micro) to fully develop. While some of the required macronutrients, such as oxygen and hydrogen, are readily available from the atmosphere, many of the other necessary nutrients that are found in the soil such as nitrogen, phosphorus, and potassium can often be in very short supply. In addition, once a crop is harvested, many of the nutrients that it relies on for healthy development and full maturation are permanently removed with it from the soil. In order to compensate for this limited supply of vital nutrients and to provide the plant with the necessary environment to fully mature, fertilizers are often added to the soil. The most essential nutrients—nitrogen, phosphorus, and potassium—are often expressed as the N-P-K ratio following the name of a fertilizer (e.g., 10-10-10).

Many sources of organic matter are available for the production of organic fertilizers, including plant and animal by-products, manure-based/biosolid products, and rock and mineral powders.

Organic fertilizers can be used to replace traditional chemical fertilizers in various applications, such as agriculture and crop production, landscaping, horticulture, parks and other recreational facilities, on school campuses, and for golf course and turf maintenance.

The following is a list of the more commonly utilized sources of organic matter that is used to produce organic fertilizers (all Hall, 1998, unless otherwise noted):

Plant By-Products

Alfalfa meal:	Contains around three percent nitrogen and is commonly used as animal feed. It is an excellent fertilizer material for horticultural applications due to the fact that it contains the hormone, Triacontanol, a plant growth regulator which makes its mineral content more effective as plant nutrients (Extremely Green Gardening Products Co., 2002).
Cottonseed meal:	A by-product of cottonseed oil manufacturing, it is a rich source of nitrogen (around 7 percent). It is often sold in the form of meal, cake, flakes, or pellets.
Fruit pomaces:	These are what remain after the juice is squeezed from the fruit. They are normally heavy, wet products and are more effective when composted before use.
Soybean meal:	Contains about 7 percent nitrogen and is similar to alfalfa in that it is most commonly used as a protein supplement for animal feed. Soybean meal can be a very effective organic fertilizer, however is usually quite expensive.
Wood ash:	Wood ash is the residue that remains after the combustion of wood or unbleached wood fiber. It has the potential to be used as a lime substitute.
Seaweed:	Usually is made of kelp that has been harvested, dried, and ground. However it may also be available in soluble solutions for foliar spray applications. Seaweed has been found to contain beneficial biostimulants that stimulate growth and increase yields of a wide variety of crops (Agro-Organics, Inc., 2002) For the most part, none of the micronutrients found in seaweed extracts is present in a sufficient quantity to solely correct deficiencies found in most soils, however

seaweed extracts applied as “tonics” have been accepted by many in the organic agricultural community due to their broad array of micronutrients.

Animal By-Products

Blood meal: Blood collected from slaughterhouse operations, which has been dried and made into a powder. It contains about 12 percent nitrogen. Once collected, blood is placed in on-site cooling tanks that utilize agitation to prevent coagulation of the fresh blood. The blood is then delivered to drying plants where it is centrifuged to remove foreign material. It is then spray dried at low temperatures and pulverized into a powder (Ingredients101.com, 2002).

Bone meal: Produced from animal bones that have been discarded during the processing of meat. It is a very rich source of phosphorus, typically containing around 12 percent. Bone meal is available in several different forms: fresh bone meal (green bone meal), bone meal (raw bone meal), steamed bone meal, and bone meal ash.

Feather meal: A common by-product of the poultry slaughter industry. Feather meal usually contains between 7 and 10 percent nitrogen. The nature of feathers is such that they tend to break down and release their nitrogen much more slowly than other fertilizers of the same price. Feather meal is produced by cooking feathers in a pressurized chamber. The resulting meal is then dried and ground into a powdered end product.

Fish meal: The clean, dried ground tissue of undercooked whole fish or fish cuttings, it contains roughly 10 percent nitrogen and about 6 percent phosphorus. It is most commonly used as an additive for animal feed, but can also be used as a fertilizer (Divakaran, 1987). Fish meal is produced by cooking raw fish material to break down some of the protein. The resulting slurry is then dehydrated through a steam heating process (Brookefield Engineering, 1999).

Fish emulsion: Nutrient contents usually vary, depending on the preparation method, but the nitrogen content is typically 4 percent regardless. Fish emulsion is sometimes fortified with chemical fertilizers. This is usually the case when nitrogen content is above 5 percent.

Leather meal:	Ground tannery waste, it usually contains 10 percent nitrogen. Leather meal is prohibited in organic agriculture because it often contains about 3 percent added chromium.

Manure-Based/ Biosolid products

Poultry manure/litter:	Usually contains between 2 and 5 percent of each of the vital nutrients. Most manure/litter fertilizers are available in a pelletized form (see below) (Hall, 1998).
Sewage sludge:	Typically available in two forms: activated (6-3-0) and composted (1-2-0) (Master Garden Products, 2002). Sewage sludge provides soil with organic matter and a number of nutrients. It is often marketed in a solid form with little odor.

Rock and Mineral Powders

When considering the use of natural materials like rock, it is important to realize that there is very little consistency from one batch to another. What applies in one region might not be pertinent in another region.

Granite dust:	Granite is mostly feldspar, a mineral that is high in potassium but has a very low solubility. This is due to the fact that feldspar is very tightly bound in its mineral structure.
Glauconite:	Commonly sold as green sand, it is another source of “slowly available” potassium. Green sand is said to have desirable effects on soil structure, however its high price usually limits its use to high-value horticultural applications.
Biotite (black mica)	Contains several percent potassium, which, due to its structure (unlike that of feldspar and greensand), is relatively available in microbially active environments. When pure biotite can be procured at a reasonable price, it can be cost-effective and useful.

Organic fertilizers are available in many forms, including: liquid solutions, granular powders, and solid pellets. However, most organic fertilizers that are manure-based, namely poultry fertilizer, are available in pellet form. The process by which manure-based organic fertilizing pellets are produced (known as pelletization) is as follows: 1) excess litter is collected from farms; 2) litter is transported to fertilizer pellet production facilities; 3) litter is heat-pasteurized to destroy harmful bacteria; 4) dried litter is passed through a hammer mill where it is reduced to the consistency of sand; 5) granulated litter is transported to a pellet mill where the litter is formed into small pellets; 6) Pellets are cooled to ambient air temperature to ensure product quality (Perdue, 2002).

Sewage sludge is mostly marketed in a pelletized form. There are plants in several cities across the country that produce sludge pellets, including Baltimore, Boston. Houston, New York City, and Tampa. Milwaukee has produced sludge pellets for 60-some years now. Sludge pellets can be made in a variety of ways. The following is one of the more typical methods that is employed:

Raw sewage is separated into wastewater and solids. The wastewater is chemically disinfected with chlorine and then discharged. The solid material (raw sludge) is placed into digesters where microbes decompose the organic solids and destroy most of the disease-causing pathogens. This sludge, which can contain up to 97 percent water, is then mixed with a coagulating agent and pressed with wide fabric belts. This acts to remove water and compress the sludge into sheets. The resulting solid (referred to as sludge cake) is then baked in a "tumble-drying" oven that destroys all pathogens and bacteria, removes up to 90 percent of the remaining water, and rotates the sludge into the final product (DeCocq, Gray, and Churchill 1998).

2. Recovered Materials Content

Organic fertilizers contain up to 100 percent recovered materials and can have a mixture of various plant, animal, and mineral content depending on the desired use and the manufacturer.

Most manure-based organic fertilizer pellets contain 100 percent litter, and have no additional products added. There are other animal-based fertilizer pellets, such as those containing fish and bone meal that use a similar pelletization process. Many of these, however, have additional organic material added, such as feather meal, alfalfa meal, and sunflower seed hull ash (Hall, 1998).

Poultry fertilizer typically is produced from poultry house litter, which includes the bedding material, manure, feathers, and spilled food. Bedding is used with broiler chickens and turkeys and may be made from sawdust, wood shavings, peanut or rice hulls, or paper (Arkansas Tech University, 2002). It is organic, but contains minimal nutritional value. A litter base consists of litter with added chemical components, such as urea, sulphate of potash, di-ammonia phosphate, iron, or other chemicals. Third-party companies are often hired to clean farms and then store and dry the poultry litter. This litter can then be purchased by companies for processing into fertilizer (Holmeister, 2002).

3. Impact on Solid Waste

The use of organic fertilizers can help reduce the amount of agricultural by-products, manufacturing and processing waste, and other materials that would otherwise have to be disposed, stockpiled, or treated. Organic materials may be combined with other waste materials, such as saw dust or wood shavings, as is the case with poultry fertilizer. The amount of these wastes diverted from the waste stream varies depending on the materials used and the size of the farm or agricultural activity that supplies the materials.

Poultry litter, in particular, presents a great opportunity for diversion of waste material. Poultry litter is collected on farms and is sometimes applied directly onto crop lands (Holmeister, 2002). Perdue-AgriRecycle's pelleted poultry fertilizer diverts approximately 149,000 tons, or 19 percent, of excess poultry litter from the solid waste stream in Delaware annually (Ferguson, 2002). It was estimated that in 1997, the annual production of poultry litter totaled 19.8 million tons, with chickens producing 14.4 million tons and turkeys producing 5.4 million tons (Farm Sanctuary Newsletter, 1998).

Conventional alternatives to pelletizing sewage sludge/biosolids as a means of disposal include landfilling, deep sea dumping, and incineration. One biosolid pellet production facility in Quincy, Massachusetts, has the capacity to produce 62,000 dry tons of pellets annually (DeCocq, Gray, and Churchill, 1998).

4. Technical Feasibility and Performance

a. Regulations and Guidelines

U.S. Code Title 7, Chapter 94, which governs organic certification, only applies to agricultural food products. However, it does state that to be certified organic, a farm must not use fertilizers containing synthetic ingredients or any fertilizer that uses phosphorus, lime, or potash as its source of nitrogen

(Cornell, 2002). In general, states regulate fertilizers through labeling and permit requirements (Scott, 2002).

The National Organic Program of the U.S. Department of Agriculture (USDA) has developed rules governing organic products, which may be grown with organic fertilizers. However, the program does not apply to the fertilizers themselves (USDA, 2002). In addition, USDA, pursuant to the recently passed Farm Bill, will be issuing guidelines on biobased products, which would support the use of fertilizers made from plant or animal matter.

The Organic Materials Review Institute (OMRI) has developed guidelines and lists of materials allowed and prohibited for use in the production, processing, and handling of organically grown products. OMRI is a 501(c)(3) nonprofit organization with the mission of publishing and disseminating generic and specific (brand name) lists of materials allowed and prohibited for use in the production, processing, and handling of organic food and fiber (OMRI, 2002).

A contact with the National Park Service (NPS) emphasized the importance of knowing the chemistry of the soil before applying fertilizer. Many times, this will influence the type of fertilizer needed. For example, for much of NPS's land in Washington, DC, the soil is already quite high in phosphorus. Therefore, one of the chemical fertilizers NPS uses has a 18-2-18 analysis, which provides only 2 percent by weight of phosphorus and higher levels of nitrogen and potassium. The contact also added that NPS follows certain general guidelines, such as aerating the soil before applying fertilizer, which reduces nonpoint source runoff if it rains soon after application (Defeo, 2002).

b. Benefits

Organic fertilizers have the potential to provide various benefits:

- Improve physical soil properties, either directly or by activating living organisms in the soil.
- Provide better soil structure as a result of soil loosening and crumb stabilization.
- Increase water-holding capacity and soil aeration.

- Enhance uptake and utilization of plant nutrients, which leads to increased pathogen resistance and hardiness.
- Slow the leaching of nutrients from soil, resulting in extended availability through the growing season.

(Quantumwide, 2002)

Chemical fertilizers can be a major source of groundwater pollution because the nitrogen is in such a soluble form that it tends to leach from the point of application. Chemical fertilizers can injure plants if they aren't washed or brushed off foliage (Clemson, 2002).

According to one manufacturer of a liquid organic fertilizer made from fish and fish frames obtained from a filleting operation, one-fourth to one-half the total nitrogen per acre should be used when using the fish-based fertilizer compared to the recommended equivalent of chemical fertilizers (Sandent Co., 2002). However, this high nitrogen property is unique to fish fertilizers. Typically, the nitrogen level of organic fertilizers is lower, so more product must be applied per acre (Defeo, 2002). The same manufacturer states that the gradual release by microorganisms in the soil for plant use provides a much more efficient transfer of nutrients from the fertilizer to the plant, and leaching is virtually eliminated. Furthermore, the company says that the alkaline fraction of the soil will continue to be reduced because organic fertilizers do not utilize salt as a carrier (Sandent Co., 2002).

As previously mentioned, nitrogen in an organic fertilizer is slow in becoming available for plant use because the nutrient must be reduced by microorganisms before it can be utilized. As such, one potential drawback to organic fertilizers is that they may not release enough of their principal nutrient at a time to give the plant what it needs for best growth. However, because organic fertilizers release their nutrients slowly, it is almost impossible to kill lawns or plants by applying too much, which is not the case with chemical fertilizers (Homestore, 2002).

The contact from NPS indicated that it is possible to find chemical fertilizers that have a high percentage of water-insoluble nitrogen, which is more slowly released than water-soluble nitrogen, mitigating some of the risk of leaching associated with water-soluble nitrogen (Defeo, 2002).

There are some drawbacks associated with certain organic fertilizers. One drawback to cottonseed meal is that there are often harmful residues in the seeds as a result of insecticide applications to cotton. As a result, most organic certification programs prohibit the use of cottonseed meal. Although wood ash can be an effective fertilizer, it may be contaminated with heavy metals or plastic, it often has a high salt content, it is rather alkaline, and excessive use can be damaging to soils. If not used properly, blood meal can burn plants with ammonia, lose much of its nitrogen through volatilization, or encourage fungal growth. The most significant problem with sludge fertilizer is the heavy metals from industrial waste and the assorted chemical contaminants from various things poured down drains. Contamination by these heavy metals and chemicals makes sludge fertilizers unsuitable for application on food crops. At least 38 states regulate the production of sludge fertilizer and its use is prohibited in all certified organic production (Hall, 1998).

5. Economic Feasibility

Organic fertilizers may be more expensive than chemical fertilizers (Clemson, 2002). The contact at Perdue-AgriRecycle indicated that the company's poultry fertilizer is marketed commercially and is priced similar to the general fertilizer market (Ferguson, 2002). In particular, blood meal and bone meal are typically very expensive (Hall, 2002). A contact with the National Park Service (NPS) indicated that the organic fertilizers they use cost $.40 to $.50 per pound, and the chemical fertilizer they use costs only $.20 per pound. Moreover, if a property required a typical application of 45 pounds of nitrogen per acre, it would require 800 pounds of the organic fertilizer vs. 200 pounds of the chemical fertilizer, further increasing the cost. NPS uses both types of fertilizer, but the contact indicated that they are probably more likely than other agencies to use a higher level of organics based simply on the nature of their work (Defeo, 2002).

6. Availability and Competition

There are only a few organic fertilizer companies that operate nationally, most have local or regional sales. According to a contact at the Organic Trade Institute, there are approximately 150 to 200 organic fertilizer manufacturers and another 200 or more companies that manufacture conventional and some organic products. These manufacturers vary in size, products, as well as the markets that they serve (Wolf, 2002).

An organic farmers survey conducted by the Organic Farming Research Foundation in Santa Cruz, California, indicates that more farmers use available on-farm materials, rather than off-farm materials (fertilizers, organic minerals, etc.) as soil amendments. Those who do purchase off-farm materials prefer organic fertilizers and soil amendments to inorganic materials (Walz,1999).

The increasing size of poultry facilities and the frequent cleaning out of many poultry operations make poultry manure available in sufficient quantities and on a timely basis to supply most fertilizer production needs (Sloan, Kidder, and Jacobs, 1996). Markets for poultry fertilizer markets are generally local, but there are various manufacturers of poultry fertilizer products operating in different states, including Delaware, Maryland, Arkansas, Indiana, Mississippi, Missouri and Pennsylvania (Ferguson, 2002).

7. Government Purchasing

Most government agencies would likely purchase fertilizers indirectly via a contracted landscaping service. However, a contact with the National Park Service indicated that an agency is at liberty to specify a particular type or nutrient analysis for any type of fertilizer (organic or synthetic) they would like to use for a particular application. NPS uses mainly two types of organic fertilizer—a product called Milorganite, which is a pelleted form made from biosolids, and Fertile Grow, which is made from poultry litter. The contact said that NPS will almost automatically use organic fertilizers for a special event for which the funding is being provided from outside the agency. For example, for an event on the National Mall, such as the Million Man March, NPS would use organic fertilizer when re-sodding following the event. Still, due to economics, using organic fertilizer for all applications would be cost-prohibited, according to the contact. Their general use fertilizer is a an 18-2-2 chemical fertilizer (Defeo, 2002)

Natural Organic Products International sells some poultry fertilizer to local cities and townships. The State of Florida also plans to purchase some poultry fertilizer for use in median landscaping (Holmeister, 2002). One manufacturer of organic fertilizer that ERG contacted sells their product to wholesale distributors, which is then sold to nurseries, golf courses, and gardening stores. Many city Parks and Recreation Departments, such as the Town of Shawnee near Kansas City, are moving towards purchasing more organic fertilizer because they find them safer than chemical fertilizer for children using those parks (Scott, 2002).

The Texas Department of Transportation (TxDOT) is currently purchasing organic fertilizer for use by its Houston District. The organic fertilizer are purchased through local suppliers. A contact at TxDOT indicated that the purchase of organic fertilizer will be increasing in the future (Markwardt, 2002).

8. Purchasing Barriers

According contacts at NPS and the General Services Administration, there are no known requirements or regulations that would prohibit government agencies from procuring organic fertilizers (McMahon, 2002 and Hicks, 2002). However, the higher cost of organic fertilizer could likely make them prohibitively expensive for overall use by most agencies.

9. Manufacturers, Distributors, and Other Contacts

a. Manufacturers and Distributors

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